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Distribution of fish species in a lake of the Amazon river floodplain near Manaus (Lago Camaleão), with special reference to extreme oxygen conditions

by

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1. Introduction

The Amazon basin has the most diverse fish fauna of a river basin on earth. To date, 1500 species have been described and it is likely that more than 2000 exist over the catchment area as a whole. The extensive literature relates principally to morphological and taxonomical aspects but there are also numerous biological studies, mostly about ornamental fish species. Ecological aspects are described by LOWE-McCONNEL (1964, 1967, 1975), MARLIER (1968), KNÖPPEL (1970), ROBERTS (1972), SOARES (1979), SANTOS (1979), GOULDING (1980), ALMEIDA (1980) and many others. These papers mostly describe the diet and feeding habits of the fish and the associated morphological and anatomical adaptations. The overall impression is that food offer is the most important factor determining species composition, distribution and abundance of the fish in Amazonian waters.

Although this is to a certain extent, and under certain conditions true, it is not necessarily the rule, as some studies have already shown. GEISLER (1969) presented data on oxygen concentrations and oxygen demand of fishes in the Rio Negro, discussing fish kills due to oxygen deficiency. GEISLER et al. (1971) stressed the eco-physiological importance of hydrochemical parameters, while in addition to food and feeding habits, ROBERTS (1972) discussed the importance of other environmental factors, e. g. light, colour of the water, salinity and oxygen concentration. SANTOS (1973) discussed the impact of hydrochemical conditions on fish migration presenting data about oxygen and H_2S concentrations during fish kills due to oxygen deficiency as a result of total mixing of the water column during cold fronts (friagens) in lakes of the Amazon river floodplain. KRAMER et al. (1978) summarized existing knowledge about Amazonian fishes in relation to the oxygen concentration of the water, pointing to the large number of already known species with morphological, anatomical and/or physiological adaptations to survival under low oxygen concentrations. VIEIRA (1982) and HOLANDA (1982) described marked differences in species composition and abundance in different areas of the Curuá-Una resevoir, the first man-made lake in Central Amazonia, discussing the importance of oxygen concentrations in the resevoir, in relation to fish distribution.

In fact, results of many limnological studies in Amazonian floodplain lakes indicate that dissolved oxygen concentrations are often very low and anoxia is frequent at least in deeper waters (MARLIER 1965; SCHMIDT 1973; SANTOS 1973; REISS 1976). Its impact on the distribution and abundance of the aquatic invertebrate fauna has already been described (JUNK 1973; IRMLER 1975; REISS 1976; BRANDORFF 1977; IRMLER and JUNK 1982). The importance of dissolved oxygen concentration on the distribution and abundance of fish species in Lago Camaleão, a lake in the Amazon floodplain (várzea) near Manaus, was studied between January 1981 and August 1982. The results are presented in this paper.

2. Description of the study area

Lago Camaleão is a narrow lake, about 6,5 km long and 100 - 300 m wide on Ilha de Marchantaria (Ilha dos Mouras), an island in the Amazon river approximately 15 km above its confluence with the Rio Negro (Fig. 1). During low water, the lake basin is normally dry, apart from a small, muddy pool, 1 - 2 ha in area and 50 - 80 cm deep. During this period the dry lake bottom is covered by terrestrial and semi-aquatic herbaceous plants, which produce considerable amounts of organic material.

When the water-level rises, the lake becomes flooded beginning at tis downstream end. The terrestrial herbaceous vegetation dies and decomposes while simultaneously, aquatic and semi-aquatic plants develop in great quantities. Grasses are the most abundant plants and cover large areas of the lake. In 1981water entered the lake area in the end of December (Fig. 2) and there were only small areas of open water until the end of April. With rising water-level the adjacent areas including the forest, which covers the higher parts and levees of the island become flooded. In April and May 1981, the lateral levees also began to flood. In some places no distinct shoreline remained, and the lake was connected with other water bodies on the island. No detectable currents were observed.

After April the areas of open water increased, because some of the most abundant aquatic grass species (*Luziola spruceana, Oryza perennis, Hymenachne amplexicaulis*) ended their growth period and started to die and decompose. However, more than 60 % of the lake surface continued to be covered with aquatic vegetation, dominated by the tough grass *Echinochloa polystachya*. During this period, free floating species like *Eichhornia crassipes* and *Salvinia auriculata* grew abundantly. At the beginning of July 1981, during peak water-

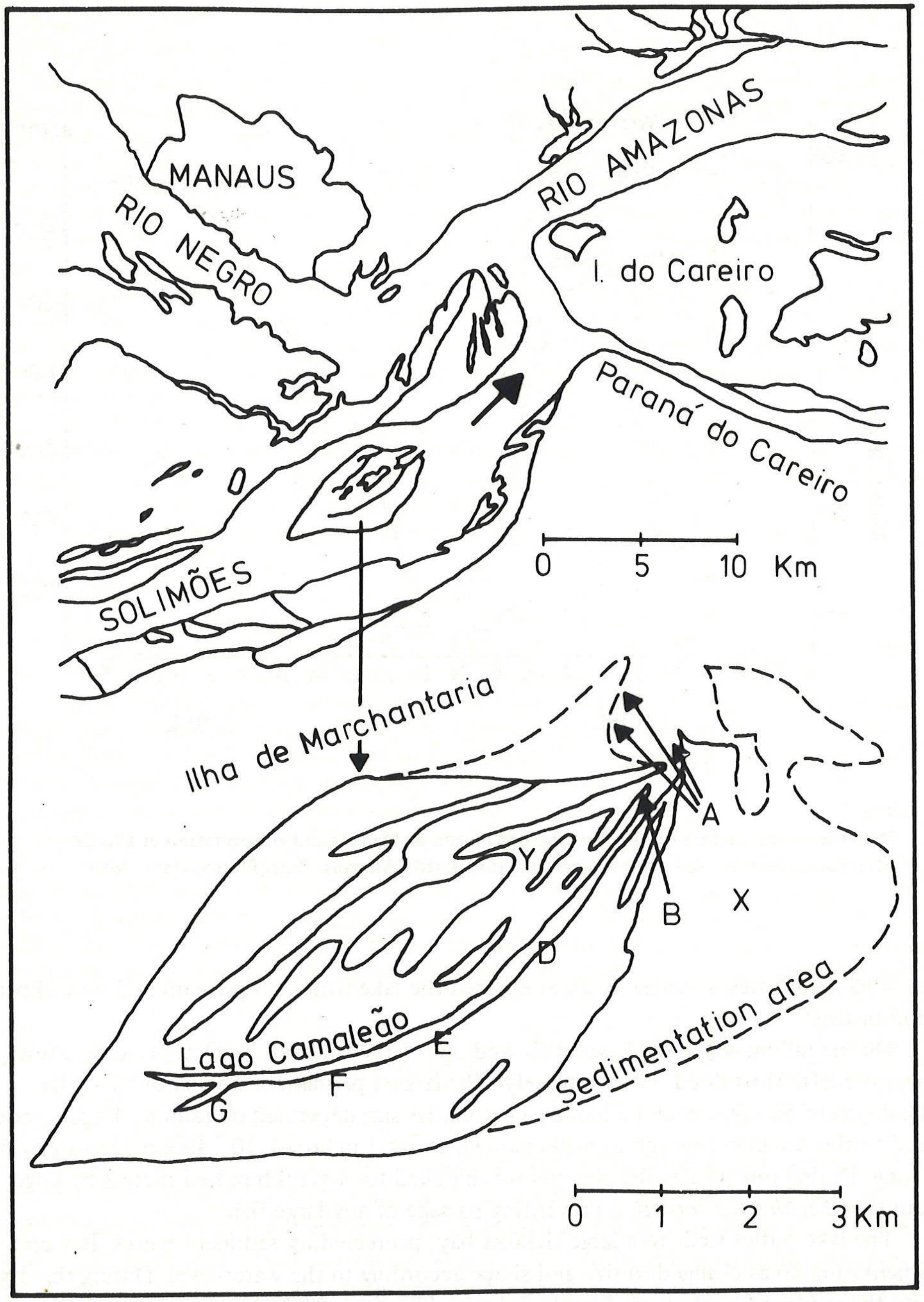

Fig. 1:
Map of the investigation area. Ilha de Marchantaria is also called Ilha dos Mouras. Size and shape of the sedimentation area changes considerably according to the water-level. Stations D, E, F and G are treated in this study as a single station, station C.

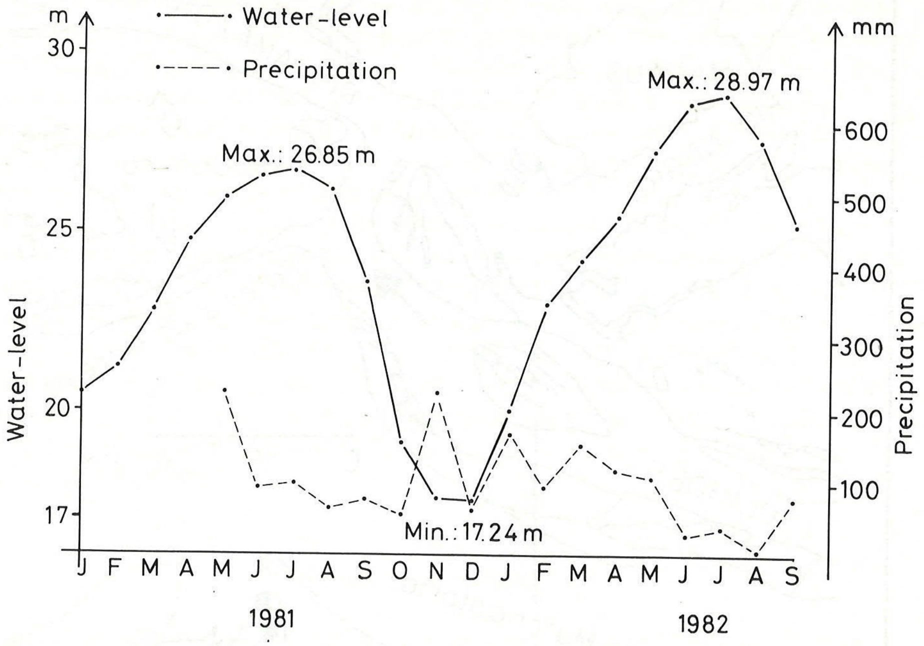

Fig. 2:
Water-level fluctuation of the Rio Negro/Amazon at Manaus and precipitation at Ilha de Marchantaria. Water-level data: Capitania dos portos, Manaus. Precipitation data: Adis.

level, small quantities of Amazon water entered the lake from its upstream end for a short period of time.

During falling water-level, water flowed out of the lake and by October only a few pools were left. Most dried out completely. The largest permanent pool about 1 - 2 ha, had a depth of 50 - 80 cm and a muddy bottom. Its size depended on rainfall. Excess water passed to the Amazon through a small channel, about 1 m broad, 10 - 40 cm deep and 1,5 km long. During our studies the channel was blocked for several hundred meters by huge amounts of *Eichhornia crassipes,* preventing passage of any large fish.

The lake outlet leads to a large shallow bay, protected by sediment banks. Bay and sedimentation areas changed in size and shape according to the water-level. During the dry period the sediment banks were heavily colonized by terrestrial and semi-aquatic herbaceous plants, occupying an area of several square kilometers. In 1982 water rose rapidly and by May had already surpassed the maximum level of 1981. River water flowed over the levees and entered the lake from the upstream end of the island, creating a strong current in the lake from May to the beginning of August. At peak flood, the whole island was inundated for several weeks.

3. Methods

Six stations were established in the area: one in the bay in front of the lake (station A), one at the lake entrance (station B), and four in the lake itself. The stations inside the lake were established in fixed places (Fig. 1). As oxygen conditions in the lake were similar at all 4 stations, they were considered as a single station (station C). The station in the bay (station A) changed as a result of changes in water-level. In the bay the aquatic macrophytes were used as reference points for fishing. Fish sampling was carried out in open water and near the vegetation, including its margins, with gillnets 25 x 2 m and with 6,9 and 12 cm mesh size, and two seines one 15 x 5 m with 8 mm mesh size, and another 45 x 14 m, with 35 mm mesh size.

Fishing with gillnets was carried out 24 hours per day at every station, using one net of each mesh size. Often heavy plant growth did not allow the normal use of seines. They were used therefore in shallow water (1,5 m), encircling a plot of vegetation. After closing the circle, the plants inside were uprooted, completely removed and all fish were caught. In the bay gillnet fishery could only occasionally be used because of losses by robbery.

Although fish sampling was only qualitative, it provided general information on the relative abundance of the species. According HESSE (1943), species were classified into 3 classes of dominance: 1 = less then 1 %; 2 = 1 - 5 %; 3 = more than 5 % of total number. The use of different fishing techniques did not allow quantitative analysis of the fish populations.

To compare the species composition of the fish fauna at the different stations the similarity quotient of SOERENSEN (1948) was used:

$$I_A = 100 \cdot 2\,b/(c + d)$$

b = number of species occurring at both stations
c = number of species occurring at one station
d = number of species occurring at the other station

For a more detailed analysis, samples of station A were subdivided into A_1 = species occurring during low water (September - December) and A_2 = species occurring during rising and high water (all other months). Station C was treated similarly; C_1 includes the species during extreme flood in 1982 (Mai - August), C_2 includes the species occurring at other times.

Oxygen concentration was determined by the WINKLER method. Oxygen microstratification was studied using the collecting method described by JUNK (1973). Samples were taken between 10:00 and 14:00 to reduce the effects of daily fluctuations of oxygen near the surface. H_2S was determined according to GOLTERMAN et al. (1978), (Colorimetric determination by methylene blue (II)). Taxonomic literature used in this study was very extensive but the following were of special interest: GOLDSTEIN (1973), GÉRY (1978) MAGO LECCIA (1978), SOARES (1978). The collected material was deposited in the fish collection of Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus.

4. Results

4.1. Oxygen conditions

Oxygen levels in the bay in front of the lake (station A) were strongly influenced by the Solimões/Amazonas. Secchi transparency fluctuated between 30 - 70 cm because of the high content of inorganic river sediments, indicating turbulence and therefore a lack of stable thermal stratification. Dissolved oxygen levels varied substantially in different areas of the bay. Surface oxygen values in the river itself varied between 4 and 5,5 mg/l, and in the bay oxygen concentrations showed a similar range of variation. Near the bottom at 8 m depth, oxygen concentration varied between 0,5 - 3,5 mg/l. During low water, supersaturation of oxygen occurred near the banks during the day because of a phytoplankton bloom. Fig. 3 shows 5 oxygen profiles at different locations in the bay in December 1981 and in May 1982.

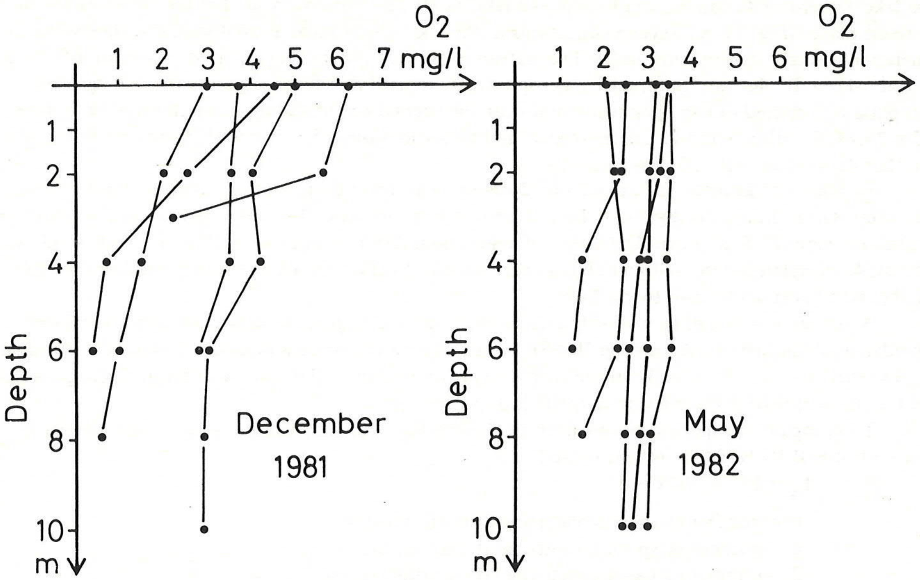

Fig. 3:
Oxygen profiles at station A in December 1981 and May 1982

In contrast to that in the bay, the water inside the lake showed pronounced deficiency of oxygen near the surface for long periods and was anoxic from 1 - 2 m below the surface, to the bottom. Small quantities of hydrogen sulphide could often be detected, even near the surface (Fig. 4). Daily changes in oxygen concentrations were observed in the surface layer, while horizontal microstratifications and small patches of increased oxygen content occurred among aquatic macrophytes (Table 1, 2).

For a short time during peak flood in July 1981, oxygen was supplied to some parts of the lake from the upstream end. In 1982, this effect was much more pronounced and lasted for a period of 4 months, because the water-level rose 2 m higher than in 1981. Another period of high oxygen concentrations occurred in November/December, when the water was at its lowest level and the lake shrank to a small, shallow pool. At this time during the day supersaturation of oxygen was observed and even in the early morning, oxygen levels were relatively high. However, for more than half the study period, surface oxygen levels in the lake were only about 0,5 mg/l, even during the day.

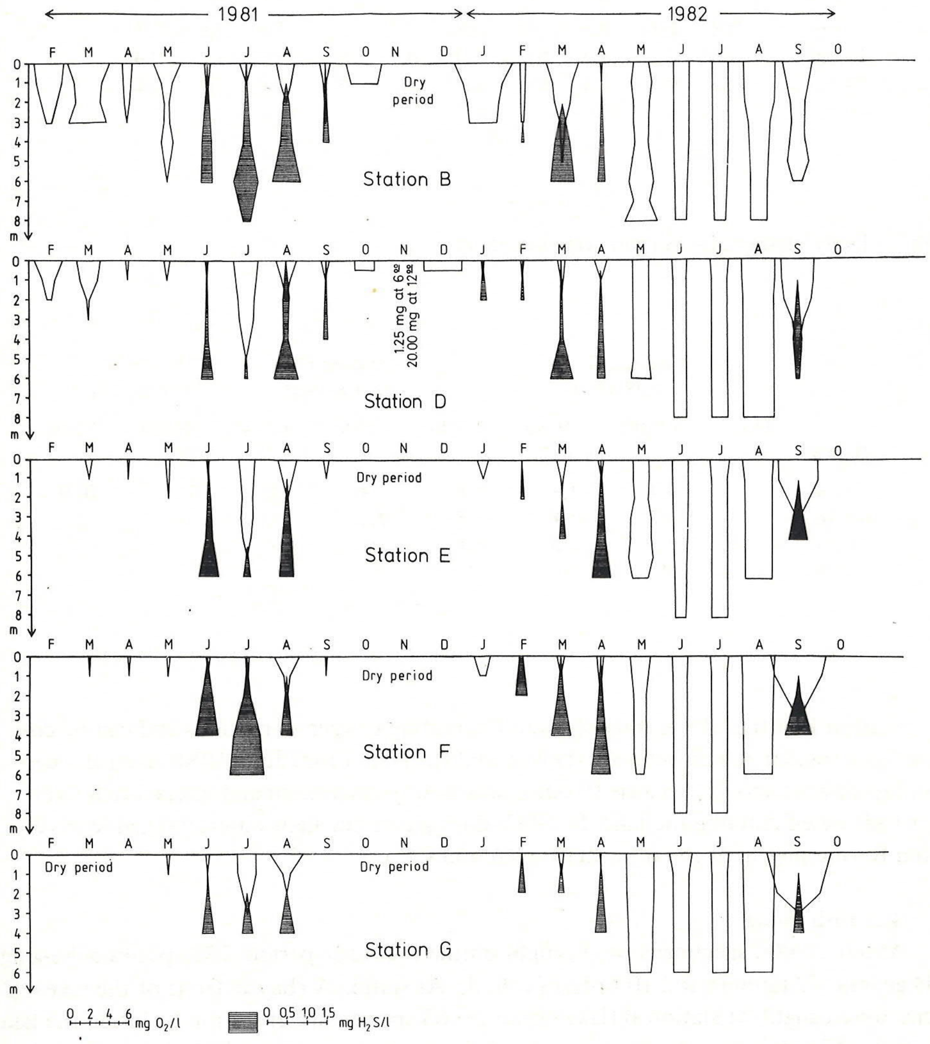

Fig. 4:
Oxygen and H_2S profiles at stations B, D, E, F and G.
H_2S measurements commenced in June 1981.

Table 1: Microstratification of oxygen in the surface water layer at station G 01.04.1981 at 11.00: I - V = free water; VI - X between emergent aquatic grasses (*Echinochloa polystachya*)

	O_2 mg/l									
Depth	I	II	III	IV	V	VI	VII	VIII	IX	X
1 cm	0,8	0,6	0,5	0,3	0,6	1,2	0,9	1,4	0,5	0,8
10 cm	0,6	0,3	0,2	0,2	0,4	0,9	0	1,2	0,2	0,4
30 cm	0,5	0,1	0,2	0,1	0,2	0	0	0,2	0,2	0,2

Table 2: Daily changes in oxygen concentration

	O_2 mg/l						
	Station G 01.08.1981			Station E 01.08.1981		Station D 03.11.1981	
Time	06:00	09:30	12:00	06:00	12:00	06:00	12:00
Depth							
0 m	0,4	0,9	1,8	1,4	2,0	1,3	20,0
0,5 m	0,2	0,4	1,8	0,2	1,0	–	–
1 m	0	0,2	1,1	0	0,6	–	–
2 m	0	0	0	0	0	–	–

Station B at the lake entrace showed fluctuating oxygen conditions and can be considered as a transition area between the bay and the lake. From June 1981 onward, deep water layers were anoxic, because flooding was near its maximum and oxygen-rich river water had ceased entering the lake. In 1982, during extreme high water, oxygen levels at station B were high as at the other stations A and C.

4.2. Fish fauna

About 25.000 specimens were caught during the study period, 132 species belonging to 94 genera, 32 families and 10 orders (Tab. 3). At station A (bay in front of the lake) 92 species were caught, at station B (lake entrance) 63 species and at station C (inside the lake) 76 species. 42 species occurred exclusively at station A, 6 species exclusively at station B, and 18 species exclusively at station C.

As the number of samples increased, the number of species found also increased (Fig. 5). However, 90 % of all species were collected during the first year of sampling. In the following 8 months the total species count increased by only 10 %. This indicates that

Tab. 3: Occurrence and relative abundance of fish species collected at the three investigated stations. 1 = rare, 2 = frequent, 3 = very frequent

	STATION A												
	1981								1982				
SPECIES	M	J	J	A	S	O	N	D	J	F	M	A	M
CLASS CHONDRICHTHYES													
SUBCLASS ELASMOBRANCHII													
ORDER RAJIFORMES													
FAMILY POTAMOTRYGONIDAE													
1 *Potamotrygon hystrix*	-	-	-	-	-	-	1	-	-	-	-	-	-
CLASS OSTEICHTHYES													
SUBCLASSE SARCOPTERYGII													
ORDER DIPTERIFORMES													
FAMILY LEPIDOSIRENIDAE													
2 *Lepidosiren paradoxa*	-	-	-	-	-	-	-	-	-	-	-	-	-
SUBCLASS ACTINOPTERYGII													
SUPERORDER CLUPEOMORPHA													
ORDER CLUPEIFORMES													
FAMILY CLUPEIDAE													
3 *Pellona castelnaeana*	-	1	1	1	2	-	1	2	2	2	1	2	-
4 *Pellona flavipinnis*	1	2	3	2	1	1	3	3	2	2	2	1	1
5 *Pellona harrower*	1	1	1	-	-	-	2	1	3	3	1	1	1
6 *Pristigaster cayana*	1	1	1	2	-	-	1	-	2	3	2	3	3
FAMILY ENGRAULIDAE													
7 *Anchoa spinifera*	2	1	1	1	-	-	1	-	-	-	-	-	-
SUPERORDER OSTARIOPHYSI													
ORDER OSTEOGLOSSIFORMES													
FAMILY OSTEOGLOSSIDAE													
8 *Osteoglossum bicirrhosum*	-	-	-	-	-	-	-	-	-	-	-	-	-
9 *Arapaima gigas*	-	-	-	-	-	-	-	-	-	-	-	-	-

	STATION B																			
	1981												1982							
SPECIES	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
CLASS CHONDRICHTHYES																				
SUBCLASS ELASMOBRANCHII																				
ORDER RAJIFORMES																				
FAMILY POTAMOTRYGONIDAE																				
1 *Potamotrygon hystrix*	-	-	-	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-
CLASS OSTEICHTHYES																				
SUBCLASSE SARCOPTERYGII																				
ORDER DIPTERIFORMES																				
FAMILY LEPIDOSIRENIDAE																				
2 *Lepidosiren paradoxa*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
SUBCLASS ACTINOPTERYGII																				
SUPERORDER CLUPEOMORPHA																				
ORDER CLUPEIFORMES																				
FAMILY CLUPEIDAE																				
3 *Pellona castelnaeana*	1	-	-	-	-	-	-	-	1	-	Dry period		3	2	-	-	-	2	1	1
4 *Pellona flavipinnis*	-	3	1	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
5 *Pellona harrower*	-	-	-	-	-	-	-	-	-	-			1	-	-	-	-	-	-	-
6 *Pristigaster cayana*	3	2	2	-	-	-	-	-	-	-			3	-	-	-	-	1	1	-
FAMILY ENGRAULIDAE																				
7 *Anchoa spinifera*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	1	1	-
SUPERORDER OSTARIOPHYSI																				
ORDER OSTEOGLOSSIFORMES																				
FAMILY OSTEOGLOSSIDAE																				
8 *Osteoglossum bicirrhosum*	-	-	-	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	1	-	-
9 *Arapaima gigas*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-

	STATION C																			
	1981												1982							
SPECIES	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
CLASS CHONDRICHTHYES																				
SUBCLASS ELASMOBRANCHII																				
ORDER RAJIFORMES																				
FAMILY POTAMOTRYGONIDAE																				
1 *Potamotrygon hystrix*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLASS OSTEICHTHYES																				
SUBCLASSE SARCOPTERYGII																				
ORDER DIPTERIFORMES																				
FAMILY LEPIDOSIRENIDAE																				
2 *Lepidosiren paradoxa*	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
SUBCLASS ACTINOPTERYGII																				
SUPERORDER CLUPEOMORPHA																				
ORDER CLUPEIFORMES																				
FAMILY CLUPEIDAE																				
3 *Pellona castelnaeana*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1
4 *Pellona flavipinnis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5 *Pellona harrower*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6 *Pristigaster cayana*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
FAMILY ENGRAULIDAE																				
7 *Anchoa spinifera*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
SUPERORDER OSTARIOPHYSI																				
ORDER OSTEOGLOSSIFORMES																				
FAMILY OSTEOGLOSSIDAE																				
8 *Osteoglossum bicirrhosum*	-	-	-	1	1	1	1	1	1	-	1	1	-	-	-	-	-	1	1	-
9 *Arapaima gigas*	-	-	-	-	-	-	-	-	1	1	1	1	-	1	-	-	-	-	-	-

Tab. 3: (cont.)

	STATION A													STATION B																				STATION C																			
	1981								1982					1981												1982								1981												1982							
SPECIES	M	J	J	A	S	O	N	D	J	F	M	A	M	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
SUPERORDER OSTARIOPHYSI																																																				
ORDER CYPRINIFORMES																																																					
SUBORDER CHARACOIDEI																																																				
FAMILY ERYTHRINIDAE																																																				
10 *Hoplias malabaricus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	-	1	1	-	-	-	-	-	-	-	-
11 *Hoplerythrinus unitaeniatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
FAMILY CTENOLUCIIDAE																																																				
12 *Boulengerella lucia*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
FAMILY ANOSTOMIDAE																																																				
13 *Schizodon fasciatum*	-	-	-	-	-	2	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1			-	-	-	-	-	-	1	1	1	2	-	1	-	-	1	-	2	1	-	-	-	-	-	1	1	1	1	1
14 *Leporinus fasciatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	1	-	1	-	1	-	-	-	-	-	-	1	1	-	-	-	-	1	-	1	-	1	1
15 *Rhytiodus microlepis*	-	-	-	-	2	2	2	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-			-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-
16 *Rhytiodus argenteofuscus*	-	-	-	-	1	1	1	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	1
17 *Abramites hypselonotus*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY HEMIODIDAE																																																				
18 *Hemiodopsis microlepis*	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY CURIMATIDAE																																																				
SUBFAMILY PROCHILODINAE																																																				
19 *Prochilodus nigricans*	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1			-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	3	1	2	2	-	1	1	-	-	1	-	-
20 *Semaprochilodus taeniurus*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-			-	-	-	2	-	-	-	-	3	3	1	1	1	-	2	-	-	-	-	-	-	2	1	1	1	-	-	-
21 *Semaprochilodus theraponura*	-	-	-	-	2	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-			-	-	-	2	-	-	-	-	1	2	-	3	3	-	-	1	3	1	1	-	-	3	3	3	1	-	-	-
SUBFAMILY CURIMATINAE																																																				
22 *Curimata (Gasterostomus) latior*	-	-	-	-	3	2	3	3	-	1	2	3	-	-	1	-	-	-	-	-	-	-	-			-	1	1	-	1	-	1	-	-	-	2	1	3	1	1	3	3	-	-	-	-	3	3	2	1	1	1	1
23 *Curimata rutiloides*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
24 *Curimata ciliata*	-	-	-	-	3	1	-	2	-	-	3	2	-	-	-	-	-	-	-	3	-	-	-			-	-	-	-	1	-	-	-	-	-	-	1	2	-	2	3	3	-	-	-	-	1	3	3	1	-	-	-
25 *Curimata laticeps*	-	-	-	-	1	2	2	3	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	Dry period		-	1	-	-	3	-	-	-	-	-	-	1	1	-	2	2	1	-	-	-	-	1	-	-	1	-	-	-
26 *Curimata isognata*	-	-	-	-	-	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27 *Curimata rhomboides*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28 *Curimata kneri*	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29 *Curimata semiornata*	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30 *Curimatella meyeri*	-	-	-	-	-	2	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Tab. 3: (cont.)

	STATION A													STATION B																				STATION C																			
	1981								1982					1981												1982								1981												1982							
SPECIES	M	J	J	A	S	O	N	D	J	F	M	A	M	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
SUBFAMILY ANODINAE																																																					
31 *Anodus (Eigenmannina) melanopogon*	-	-	2	-	3	3	3	3	2	2	3	2	1	-	-	1	-	-	2	-	-	-	-			2	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-
32 *Anodus elongatus*	-	-	-	-	1	1	1	3	1	2	-	1	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY SERRASALMIDAE																																																					
SUBFAMILY SERRASALMINAE																																																					
33 *Serrasalmus elongatus*	-	-	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1
34 *Serrasalmus rhombeus*	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		Dry period	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35 *Serrasalmus nattereri*	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-			-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	1	1	3	1
36 *Serrasalmus* sp.	-	-	-	-	-	2	2	3	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1			-	-	-	-	1	1	-	1	1	1	-	-	-	1	1	1	1	-	-	-	-	-	-	-	1	1	1	3
37 *Pristobrycon calmoni*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1
SUBFAMILY MYLEINAE																																																					
38 *Myleus* sp.	-	-	-	-	-	-	1	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39 *Mylossoma aureum*	-	-	-	-	2	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40 *Mylossoma duriventre*	-	-	-	-	3	3	1	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-			-	1	-	-	1	1	-	-	1	1	-	1	2	-	1	-	1	-	-	-	-	2	1	1	1	1	1	1
41 *Colossoma macropomum*	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	1	-	3	-	-	-	-	-		Dry period	-	-	-	-	1	-	1	-	3	-	-	1	1	2	3	1	1	-	1	2	3	2	1	1	-	1	2	-
42 *Colossoma bidens*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	-	-	-	-	-	-	-	-	1	-	-
FAMILY CHARACIDAE																																																					
SUBFAMILY AGONIATINAE																																																					
43 *Agoniates anchovia*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-
SUBFAMILY RHAPHIODONTINAE																																																					
44 *Rhaphiodon vulpinus*	-	-	-	-	3	1	2	3	1	1	1	-	-	-	1	-	-	-	-	-	-	-	-			1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-
45 *Rhaphiodon gibbus*	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46 *Hydrolycus scomberoides*	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
SUBFAMILY CHARACINAE																																																					
47 *Acestrorhynchus falcatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		Dry period	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
48 *Charax* sp.	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49 *Eucynopotamus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
50 *Roeboides* sp.	-	-	-	-	3	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-

Tab. 3: (cont.)

STATION A

SPECIES	1981								1982				
	M	J	J	A	S	O	N	D	J	F	M	A	M
SUBFAMILY BRYCONINAE													
51 *Brycon* cf. *melanopterus*	-	1	-	-	-	-	-	-	-	-	-	1	-
52 *Triportheus angulatus*	-	1	-	1	1	2	-	1	-	1	-	2	-
53 *Triportheus albus*	2	3	1	3	3	1	-	1	-	1	-	1	-
54 *Triportheus elongatus*	-	1	-	-	1	-	-	1	-	1	1	1	-
55 *Triportheus culter*	-	-	-	-	1	-	-	-	-	-	-	-	-
SUBFAMILY TETRAGONOPTERINAE													
56 *Ctenobrycon spilurus hauxwellianus*	-	-	-	-	-	-	-	-	-	-	-	-	-
57 *Tetragonopterus argenteus*	-	-	-	-	-	-	-	-	-	-	-	-	-
58 *Odontostilbe fugitiva*	-	-	-	-	-	-	-	-	-	-	-	-	-
SUBORDER GYMNOTOIDEI													
FAMILY STERNOPYGIDAE													
59 *Eigenmannia virescens*	-	-	1	2	-	-	-	-	-	-	-	-	-
60 *Distocyclus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
61 *Rhabdolychops* sp.	-	1	-	-	-	-	-	-	-	-	-	-	-
FAMILY RHAMPHICHTHYIDAE													
62 *Rhamphichthys* sp.	-	-	-	-	1	-	2	-	-	-	-	-	-
63 *Hypopomus* sp.	-	-	-	-	-	-	1	-	-	-	-	-	-
64 *Steatogenys* sp.	-	-	-	-	-	-	1	-	-	-	-	-	-
FAMILY APTERONOTIDAE													
65 *Apteronotus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
66 *Odontosternarchus* sp.	-	-	-	-	-	-	1	-	-	1	1	1	-
67 *Porotergus gimbellis*	-	1	1	-	-	-	-	-	-	-	-	-	-
68 *Porotergus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
69 *Sternarchorhamphus* sp.	-	-	1	1	-	-	-	1	1	1	1	1	1
70 *Sternarchorhynchus* sp.	-	-	-	-	-	-	1	-	-	-	-	-	-
FAMILY GYMNOTIDAE													
71 *Gymnotus carapo*	-	-	-	-	-	-	-	-	-	-	-	-	-

STATION B

SPECIES	1981												1982							
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
SUBFAMILY BRYCONINAE																				
51 *Brycon* cf. *melanopterus*	-	-	-	-	-	-	1	-	-	-			-	2	2	2	-	1	-	-
52 *Triportheus angulatus*	-	-	-	-	-	2	3	2	-	-			-	3	2	3	3	2	2	2
53 *Triportheus albus*	-	-	-	3	3	3	3	3	3	-			3	3	3	3	3	3	3	3
54 *Triportheus elongatus*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
55 *Triportheus culter*	-	-	-	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-
SUBFAMILY TETRAGONOPTERINAE																				
56 *Ctenobrycon spilurus hauxwellianus*	-	-	-	-	3	-	2	-	-	-			-	2	-	-	3	-	2	-
57 *Tetragonopterus argenteus*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
58 *Odontostilbe fugitiva*	-	-	-	-	1	-	-	-	-	-			-	-	-	-	-	-	-	-
SUBORDER GYMNOTOIDEI																				
FAMILY STERNOPYGIDAE																				
59 *Eigenmannia virescens*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
60 *Distocyclus* sp.	1	-	1	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
61 *Rhabdolychops* sp.	-	-	-	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-
FAMILY RHAMPHICHTHYIDAE																				
62 *Rhamphichthys* sp.	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
63 *Hypopomus* sp.	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
64 *Steatogenys* sp.	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
FAMILY APTERONOTIDAE																				
65 *Apteronotus* sp.	1	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
66 *Odontosternarchus* sp.	1	-	1	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
67 *Porotergus gimbellis*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
68 *Porotergus* sp.	1	-	-	-	-	-	-	-	-	-			1	-	-	-	-	-	-	-
69 *Sternarchorhamphus* sp.	-	-	-	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-
70 *Sternarchorhynchus* sp.	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
FAMILY GYMNOTIDAE																				
71 *Gymnotus carapo*	-	-	-	-	-	-	-	-	1	-			-	-	-	-	-	-	-	-

STATION C

SPECIES	1981												1982							
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
SUBFAMILY BRYCONINAE																				
51 *Brycon* cf. *melanopterus*	2	1	-	1	1	-	1	1	2	-	-	-	-	2	1	1	1	1	1	1
52 *Triportheus angulatus*	2	2	3	3	3	3	2	3	3	2	-	-	2	3	2	3	2	3	2	3
53 *Triportheus albus*	3	3	3	3	3	2	2	3	3	-	-	-	3	3	2	3	3	3	3	2
54 *Triportheus elongatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55 *Triportheus culter*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SUBFAMILY TETRAGONOPTERINAE																				
56 *Ctenobrycon spilurus hauxwellianus*	3	3	3	1	2	-	1	-	3	3	1	1	-	3	1	-	-	-	1	1
57 *Tetragonopterus argenteus*	1	2	-	-	-	-	-	-	-	1	-	-	-	-	1	1	2	-	-	-
58 *Odontostilbe fugitiva*	3	3	3	-	-	-	1	-	2	3	1	1	-	3	-	-	-	-	-	-
SUBORDER GYMNOTOIDEI																				
FAMILY STERNOPYGIDAE																				
59 *Eigenmannia virescens*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
60 *Distocyclus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
61 *Rhabdolychops* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY RHAMPHICHTHYIDAE																				
62 *Rhamphichthys* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63 *Hypopomus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64 *Steatogenys* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY APTERONOTIDAE																				
65 *Apteronotus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66 *Odontosternarchus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
67 *Porotergus gimbellis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68 *Porotergus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69 *Sternarchorhamphus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70 *Sternarchorhynchus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY GYMNOTIDAE																				
71 *Gymnotus carapo*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1

Tab. 3: (cont.)

	STATION A													STATION B																				STATION C																			
	1981								1982					1981												1982								1981												1982							
SPECIES	A	J	J	A	S	O	N	D	J	F	M	A	M	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
FAMILY ELECTROPHORIDAE																																																					
72 *Electrophorus electricus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ORDER SILURIFORMES																																																					
FAMILY DORADIDAE																																																					
73 *Anadoras* cf. *grypus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
74 *Lithodoras dorsalis*	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75 *Opsodoras parallelus*	-	-	-	-	-	-	-	-	1	1	1	1	-	-	3	1	-	-	-	-	-	3	-	Dry period		2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
76 *Opsodoras trimaculatus*	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77 *Opsodoras* sp.	2	3	-	-	-	1	-	2	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
78 *Pseudodoras niger*	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
79 *Pterodoras granulosus*	1	-	-	-	-	-	1	1	2	2	3	2	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
80 *Hassar* sp.	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
81 *Trachydoras* cf. *atripes*	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY AUCHENIPTERIDAE																																																					
82 *Auchenipterus* cf. *nuchalis*	1	1	2	-	2	-	-	-	-	1	-	1	-	-	-	1	-	-	-	-	-	-	-			1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
83 *Centromochlus heckeli*	2	2	2	3	1	-	-	-	1	-	-	-	-	1	1	3	-	-	-	-	-	-	-	Dry period		1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	1	-
84 *Trachycorystes* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1			-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	-	-	-	-	-	-	-	1	1	-
FAMILY AGENEIOSIDAE																																																					
85 *Ageneiosus dentatus*	1	1	1	-	-	1	1	1	2	2	2	2	1	1	-	-	-	-	-	-	-	-	-			2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-
86 *Ageneiosus brevifilis*	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
87 *Ageneiosus* sp.	1	-	1	1	-	1	1	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
88 *Tympanopleura* sp.	-	-	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY CALOPHYSIDAE																																																					
89 *Calophysus macropterus*	1	-	-	-	-	1	2	2	1	1	1	-	-	-	-	-	-	-	-	-	-	1	-	Dry period		-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-

Tab. 3: (cont.)

	STATION A												
	1981								1982				
SPECIES	M	J	J	A	S	O	N	D	J	F	M	A	M
FAMILY PIMELODIDAE													
90 *Pimelodus* sp.	1	2	1	-	1	1	-	2	-	1	-	-	-
91 *Pimelodus* cf. *altipinnis*	-	-	1	-	-	2	2	1	1	-	-	1	1
92 *Pimelodella cristata*	-	-	-	-	-	-	-	1	-	-	-	-	-
93 *Pimelodina* sp.	-	-	-	-	-	1	1	1	1	1	-	-	-
94 *Pseudoplatystoma tigrinum*	-	-	-	-	-	1	-	-	-	-	-	-	-
95 *Pseudoplatystoma fasciatum*	-	-	-	-	-	1	-	-	-	-	-	-	-
96 *Brachyplatystoma vailanti*	-	-	-	-	-	-	-	-	-	-	1	-	-
97 *Brachyplatystoma flavicans*	-	-	1	-	-	-	-	-	-	-	-	-	1
98 *Brachyplatystoma* sp.	1	-	-	1	-	-	-	-	1	-	-	-	-
99 *Sorubim* cf. *lima*	-	-	-	1	1	1	-	1	-	-	-	-	-
100 *Pinirampus pirinampu*	1	-	1	-	-	1	2	2	1	1	1	1	-
101 *Platynematichthys notatus*	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY HYPOPHTHALMIDAE													
102 *Hypophthalmus perporosus*	3	3	3	3	1	2	2	2	2	2	3	1	1
103 *Hypophthalmus fimbriatus*	-	-	1	-	-	1	-	-	-	-	1	-	-
104 *Hypophthalmus edentatus*	-	-	-	-	1	1	1	-	-	-	-	-	-
FAMILY TRICHOMYCTERIDAE*													
105 *Vandellia* sp.	1	1	1	1	1	1	2	1	1	1	1	1	1
FAMILY CETOPSIDAE													
106 *Cetopsis* sp.	-	-	-	-	-	1	1	-	-	-	-	-	-
FAMILY CALLICHTHYIDAE													
107 *Hoplosternum thoracatum*	-	-	-	-	-	-	3	2	-	-	-	1	-
108 *Corydoras* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-
109 *Callichthys callichthys*	-	-	-	-	-	-	1	1	-	-	-	-	-

	STATION B																			
	1981												1982							
SPECIES	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
FAMILY PIMELODIDAE																				
90 *Pimelodus* sp.	-	-	-	-	1	-	-	-	-	-			1	-	-	-	-	-	-	-
91 *Pimelodus* cf. *altipinnis*	3	-	3	-	-	-	-	-	1	-			-	-	-	-	-	-	-	-
92 *Pimelodella cristata*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
93 *Pimelodina* sp.	-	-	-	-	-	-	-	-	-	-			-	-	-	-	1	-	-	-
94 *Pseudoplatystoma tigrinum*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
95 *Pseudoplatystoma fasciatum*	-	-	-	-	1	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-
96 *Brachyplatystoma vailanti*	-	1	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
97 *Brachyplatystoma flavicans*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	1
98 *Brachyplatystoma* sp.	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
99 *Sorubim* cf. *lima*	-	-	1	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
100 *Pinirampus pirinampu*	1	-	1	-	1	-	-	-	-	-			1	1	-	-	-	-	-	-
101 *Platynematichthys notatus*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	1
FAMILY HYPOPHTHALMIDAE																				
102 *Hypophthalmus perporosus*	3	3	3	-	-	-	-	-	1	-			1	-	-	-	1	1	1	-
103 *Hypophthalmus fimbriatus*	1	-	1	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-
104 *Hypophthalmus edentatus*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
FAMILY TRICHOMYCTERIDAE*																				
105 *Vandellia* sp.	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
FAMILY CETOPSIDAE																				
106 *Cetopsis* sp.	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
FAMILY CALLICHTHYIDAE																				
107 *Hoplosternum thoracatum*	-	-	-	-	-	-	-	-	-	-			-	1	-	-	-	-	-	1
108 *Corydoras* sp.	-	-	-	-	1	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-
109 *Callichthys callichthys*	-	-	-	-	1	-	-	-	-	-			-	-	-	-	-	-	-	-

	STATION C																			
	1981												1982							
SPECIES	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	**A**
FAMILY PIMELODIDAE																				
90 *Pimelodus* sp.	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
91 *Pimelodus* cf. *altipinnis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
92 *Pimelodella cristata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
93 *Pimelodina* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
94 *Pseudoplatystoma tigrinum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
95 *Pseudoplatystoma fasciatum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
96 *Brachyplatystoma vailanti*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
97 *Brachyplatystoma flavicans*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
98 *Brachyplatystoma* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
99 *Sorubim* cf. *lima*	-	1	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
100 *Pinirampus pirinampu*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
101 *Platynematichthys notatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
FAMILY HYPOPHTHALMIDAE																				
102 *Hypophthalmus perporosus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	2
103 *Hypophthalmus fimbriatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
104 *Hypophthalmus edentatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
FAMILY TRICHOMYCTERIDAE*																				
105 *Vandellia* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY CETOPSIDAE																				
106 *Cetopsis* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY CALLICHTHYIDAE																				
107 *Hoplosternum thoracatum*	2	3	-	1	1	3	2	-	1	1	3	3	2	1	2	-	1	1	1	1
108 *Corydoras* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
109 *Callichthys callichthys*	-	-	-	1	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-

* 2 species collected

Tab. 3: (cont.).

	STATION A													STATION B																				STATION C																			
	1981								1982					1981												1982								1981												1982							
SPECIES	M	J	J	A	S	O	N	D	J	F	M	A	M	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
FAMILY LORICARIIDAE																																																					
110 *Loricariichthys acutus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
111 *Loricariichthys* cf. *platymetopan*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
112 *Pterygoplichthys multiradiatus*	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	1	-	-	-	-	-	-	1	2	-	1	1	-	1	-	1	-	3	3	3	1	1	-	1	1	-	-
113 *Hemiodontichthys occipenserinus*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114 *Sturisoma* sp.	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115 *Plecostomus* sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SUPERORDER ACANTHOPTERYGII																																																					
ORDER SYNBRANCHIFORMES																																																						
FAMILY SYNBRANCHIDAE																																																					
116 *Synbranchus marmoratus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-	1	1	1	-	-	-	-	-	-	-
ORDER PERCIFORMES																																																					
SUBORDER PERCOIDEI																																																					
FAMILY SCIAENIDAE																																																					
117 *Plagioscion surinamensis*	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry period		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118 *Plagioscion montei*	-	-	1	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
119 *Plagioscion squamosissimus*	1	1	1	-	1	1	3	3	3	1	1	1	-	-	-	-	-	-	-	-	-	-	-			1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY CICHLIDAE																																																					
120 *Apistogramma* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
121 *Acarichthys heckelli*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
122 *Astronotus ocellatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1			-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	-	1	-	3	3	-	-	-	-	-	1	-	-
123 *Chaetobranchus flavescens*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-
124 *Cichla ocellaris*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
125 *Cichlasoma bimaculatum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	1	Dry period		-	-	-	-	-	-	-	-	1	1	1	1	-	-	1	-	1	1	1	1	1	-	-	-	-	-	-	-
126 *Cichlasoma festivum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3			-	-	-	-	-	-	-	1	1	1	1	-	-	-	-	-	3	3	1	1	-	-	-	-	-	-	-	2
127 *Cichlasoma severum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1			-	-	-	-	-	-	-	-	-	1	1	-	-	1	1	-	1	3	3	2	-	-	-	-	1	-	1	-
128 *Cichlasoma temporale*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
129 *Pterophyllum scalare*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	1	-	-	-	-	-	-	-	-
130 *Crenicichla saxatilis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Tab. 3: (cont.)

STATION A

SPECIES	1981								1982				
	M	J	J	A	S	O	N	D	J	F	M	A	M
ORDER TETRAODONTIFORMES													
FAMILY TETRAODONTIDAE													
131 *Colomesus asellus*	1	-	1	-	1	-	-	-	-	-	-	-	-
ORDER ATHERINIFORMES													
FAMILY BELONIDAE													
132 *Pseudotylosurus* sp.	-	-	1	-	1	-	-	-	-	-	-	-	-
Number of species:	19	19	26	15	42	47	42	43	21	29	28	30	13

STATION B

SPECIES	1981												1982							
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
ORDER TETRAODONTIFORMES																				
FAMILY TETRAODONTIDAE											Dry period									
131 *Colomesus asellus*	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
ORDER ATHERINIFORMES																				
FAMILY BELONIDAE																				
132 *Pseudotylosurus* sp.	-	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-
Number of species:	13	9	19	1	13	3	5	2	10	11			15	11	4	6	14	12	12	13

STATION C

SPECIES	1981												1982							
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
ORDER TETRAODONTIFORMES																				
FAMILY TETRAODONTIDAE																				
131 *Colomesus asellus*	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ORDER ATHERINIFORMES																				
FAMILY BELONIDAE																				
132 *Pseudotylosurus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of species:	17	20	13	23	23	14	22	15	34	17	16	16	8	17	16	12	27	30	28	26

Station	A	B	C	Total
Number of species	92	63	76	132
Number of genera	61	50	61	94
Number of families	24	21	24	32
Number of orders	7	5	8	10
Number of species exclusive to station	42	6	18	66

almost all the species which could be captured in the area using the available fishing gear and methods have actually been captured.

This statement has to be modified, with respect to the individual sampling stations. For easier comparison, numbers of species at station A from January to April 1982 were plotted for 1981. A pronounced increase in total numbers was seen at the beginning of the sampling period. A second pronounced increase occurred during the dry period but after both periods of marked species number increase there were periods when species numbers increased only slowly. Species numbers at station A seems to remain relatively constant at the end of the sampling period (Fig. 5).

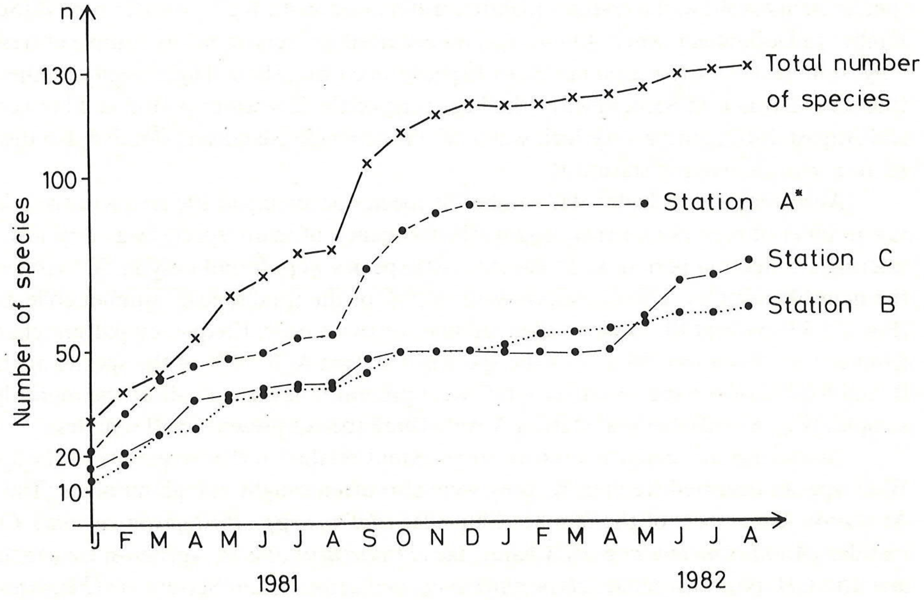

Fig. 5:
Accumulative number of species collected in the study area and at the different stations

Station B showed a more or less linear increase in species number with the number of samples. However, the fish fauna at station B includes chiefly species which also occurred at station A and/or C. Only 6 species were captured exclusively at station B. It can therefore, be assumed that further sampling at station B would increase the species list of this station, but only slighly increase the total number of species captured in the whole area.

At station C, species number increased in step-wise, periods of pronounced increase in species numbers were interrupted by periods where species numbers remained nearly constant. Periods of species number increase occurred at the beginning of the sampling period, at the beginning of the low water period and during the maximum flood in 1982. Station C shows a marked period of species increase during the last four months of sampling, indicating that species numbers at this station had not reached the maximum (Fig. 5).

Despite the high number of species occurring in the study area, the number of species caught monthly was relatively low. Highest species numbers were found during low water period from September to December. In October, species number reached its maximum with 73 species corresponding to 55 % of the total number. During rising and high water-level total species number collected monthly was considerably lower, varying between 21 - 47 species only (= 16 - 36 % of total species number (Fig. 6)). Generally, species richness was greatest in the samples at station A, and poorest at station B (Fig. 6). Patterns of species richness showed a distinct maximum at station A during low water period (September to December), when 40 - 47 species occurred in every monthly sample corresponding to 46 - 51 % of the total number of species occurring there. High species richness was found in station C in September at the beginning of the low water period and between June and August 1982, during very high water when the whole island was flooded. No distinct pattern was observed at station B.

According to the high total number of species occurring in the area and the relative low number of species monthly caught, the frequency of many species was very low. Considering a collection period of 20 months, 105 species were found only in 50 % or less of the monthly samples. This corresponds to 79,5 % of the total species number collected (Fig. 7). 53 species (40 %) were collected ones or twice only. Frequency pattern changed from station to station. 76,1 % of the species at station A, 95,2 % of the species at station B, and 84,2 % of the species at station C were present in less than half of the monthly samples (Fig. 8 - 10). Only at station A were three species present in all samples.

Abundance of specimens was to some extent related to the frequency of the species. When species occurred frequently, they were also often caught in high numbers (Tab. 3). At station A members of the families Clupeidae (*Pellona* spp., *Pristigaster cayana*), Curimatidae (*Anodus melanopogon*), Characidae (*Triportheus albus*), Ageneiosidae (*Ageneiosus dentatus*), Hypophthalmidae (*Hypophthalmus perporosus*), and Sciaenidae (*Plagioscion squamosissimus*) were most abundant during the entire sampling period. At station B only *Triportheus albus* (Characidae) occurred frequently in large numbers. At station C members of the families Curimatidae (*Semaprochilodus* spp., *Curimata* spp.) Serrasalmidae (*Colossoma macropomum*), Characidae (*Brycon* cf. *melanopterus, Triportheus* spp., *Ctenobrycon spilurus hauxwellianus, Odontostilbe fugitiva*), Callichthyidae (*Hoplosternum thoracatum*), Loricariidae (*Pterigoplichthys multiradiatus*), and Cichlidae (*Cichlasoma* spp.) were often abundant. At station A some species occurred with increased numbers during the period of low water, sometimes their occurrence being limited to this period, e. g. *Rhytiodus microlepis* (Anostomidae), *Curimata* spp. (Curimatidae), *Serrasalmus* sp., *Mylossoma* spp. (Serrasalmidae), *Raphiodon vulpinus* (Characidae) (Tab. 3). In some cases, however, species occurred only once or twice during the entire sampling period, but then abundantly, e. g. *Auchenipterus nuchalis* (Auchenipteridae) at station C.

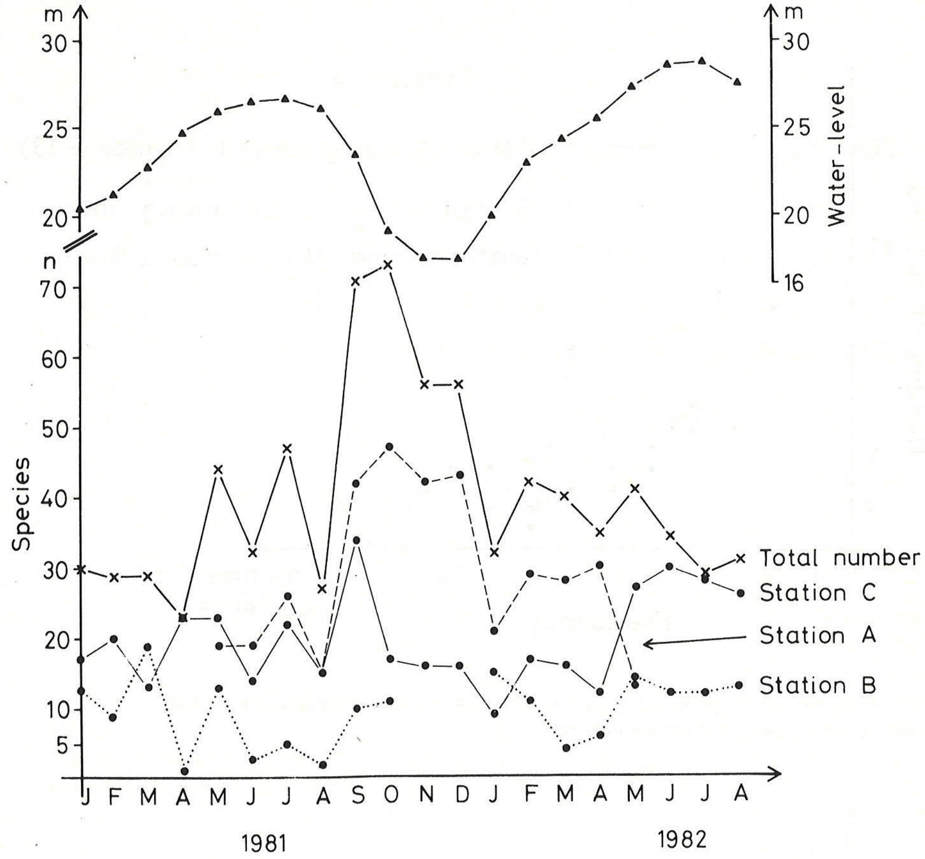

Fig. 6:
Species number collected monthly in the study area and at the different stations

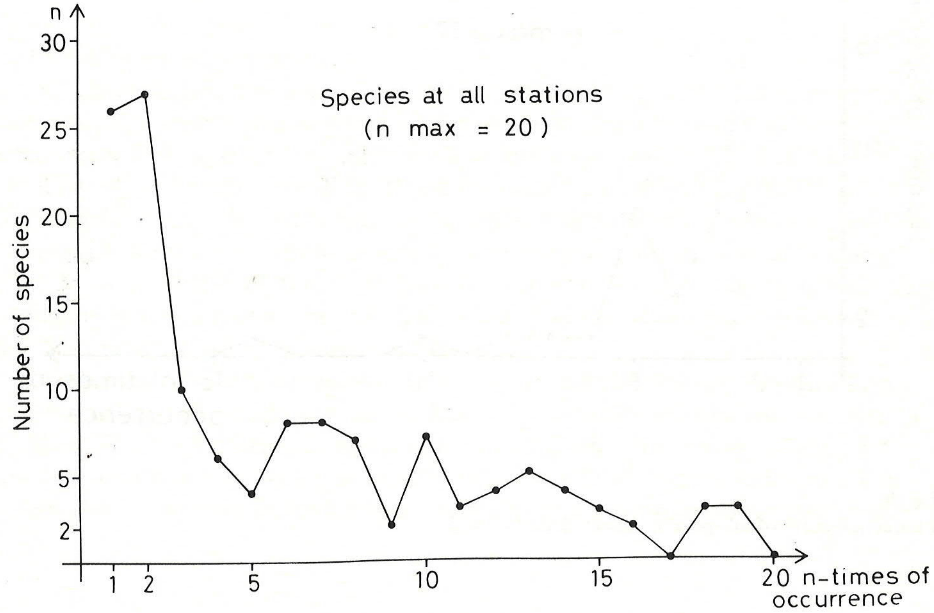

Fig. 7:
Frequency-curve of all species, collected in the area during 20 month of sampling

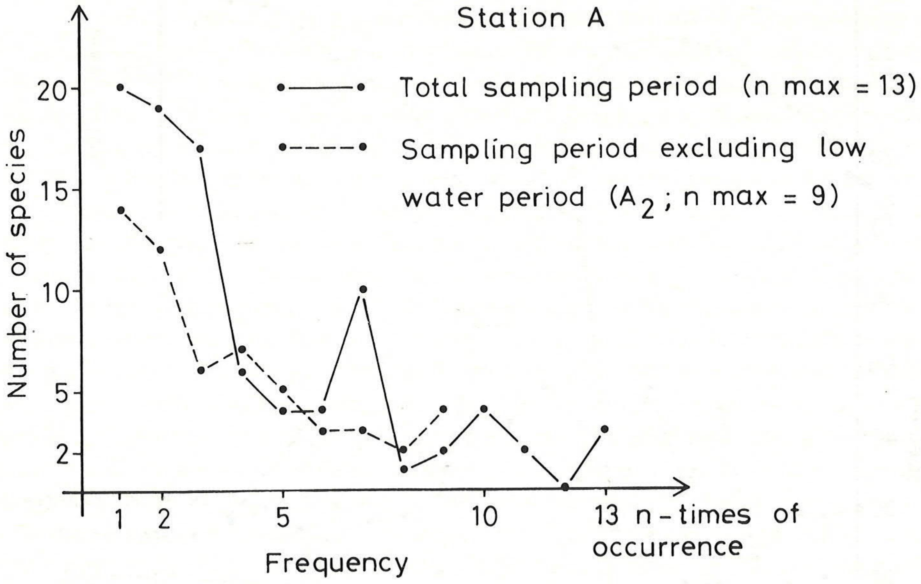

Fig. 8:
Frequency-curve of all species, collected at station A and of the species collected at station A during rising and high water-level (A_2)

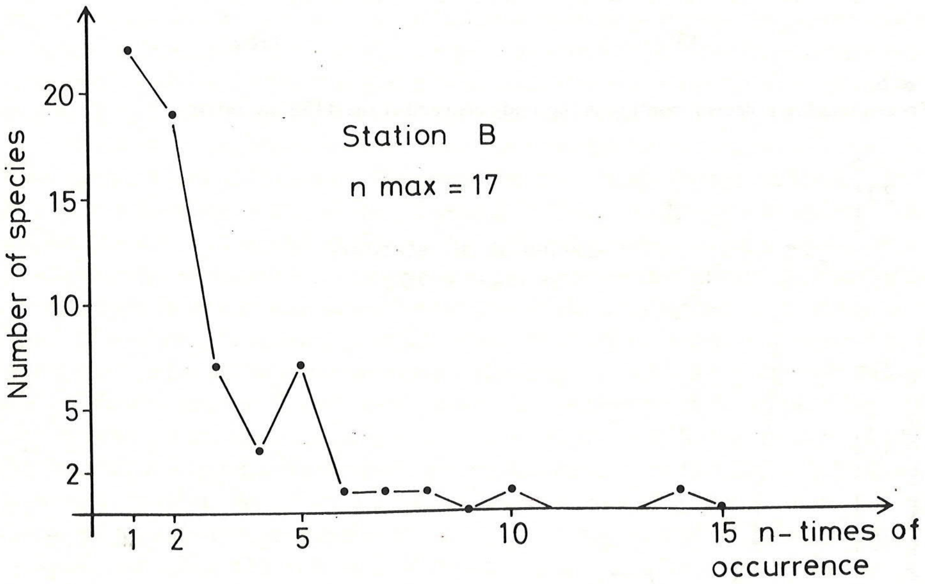

Fig. 9:
Frequency-curve of all species, collected at station B

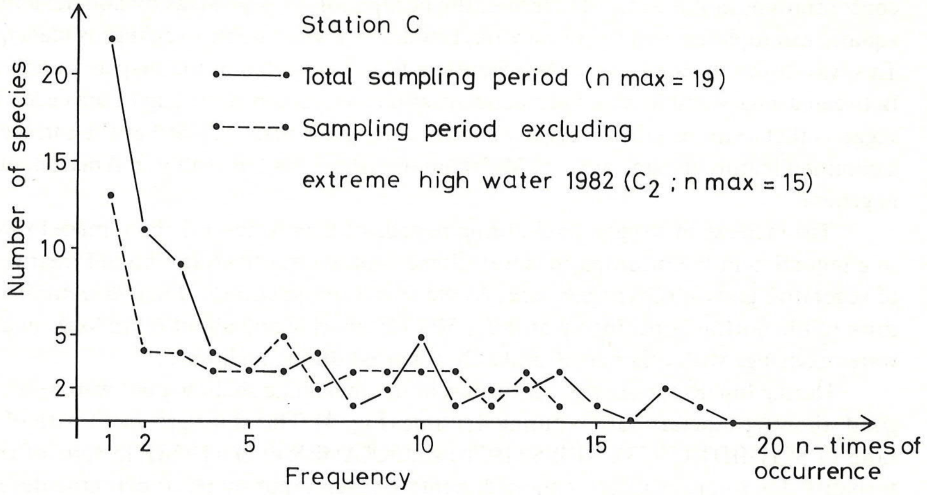

Fig. 10:
Frequency-curve of all species collected at station C and of the species collected at station C, excluding the period of extreme high water from May - August 1982 (C_2)

5. Discussion

5.1. Oxygen concentrations

Oxygen deficiency is common in Lago Camaleão for long periods of the year. Earlier investigations in Amazonian floodplain lakes have shown that low oxygen concentrations are a common feature at least in deeper waters (GESSNER 1961; GEISLER 1969; SCHMIDT 1973; SANTOS 1973; BRINKMANN and SANTOS 1973; REISS 1976; BRANDORFF 1977; KRAMER et al. 1978; JUNK 1980). However concentrations below 0,5 mg/l (= 6,6 % air saturation at 30 °C) at the surface have seldom been reported (SANTOS 1973; BRINKMANN and SANTOS 1974). Furthermore, it has to be remembered that the values here reported were measured at noon, so that lower values and even anoxia are to be expected in early morning near the surface.

However, it would be erroneous to conclude, that such extremely low values are exceptional and hardly representative of lakes in the Amazonian floodplain. Our observations show that oxygen levels are higher when there are large areas of open water, and when only a small percentage of the total areas is covered with aquatic and semiaquatic macrophytes. Open areas facilitate oxygen input through phytoplankton growth, and diffusion from the air. Submersed and floating aquatic and semi-aquatic macrophytes not only reduce windinduced turbulence and shade phytoplankton, but they also produce large amounts of organic material. Decomposition processes greatly reduce the oxygen concentrations in the water. Therefore, the occupation of large areas by aquatic and semi-aquatic macrophytes indicates heavy oxygen deficits when water exchange is inadequate. This was shown in two areas on Marchantaria Island indicated in the map as x and y. Between January and May oxygen concentration were as low as in Lago Camaleão. This suggests that extremely low oxygen concentrations, less than 0,5 mg/l at the surface, are a common feature in large areas of Marchantaria Island, and probably in Amazonian várzeas in general.

The increase in oxygen level during periods of high water in Lago Camaleão was due to a reduction in the macrophyte cover. Some common species had finished their period of vegetative growth (*Oryza perennis, Hymenachne amplexicaulis, Luziola spruceana*) and sunk to the bottom, opening up an area, 50 - 150 m wide and about 6 km long. In addition water exchange with other areas probably occurred during high water.

During low water oxygen conditions in the remaining shallow pool were relatively good, showing supersaturation during daytime (Fig. 4). This is in agreement with observations of SCHMIDT (1973), REISS (1976) and KRAMER et al. (1978). In spite of the high turbidity due to disturbance of the sediments, oxygen input by phytoplankton development and diffusion was sufficient to surpass the oxygen demand by decomposition processes overnight. During this period floating macrophytes occurred in small quantities only.

During peak water-levels water exchange in the lakes of Marchantaria island is relatively fast, improving the oxygen conditions. In 1981 flooding was not sufficient to have a strong impact on the island. In 1982, the Amazon flowed over the entire island, with current velocities of 30 - 100 cm . sec^{-1} in the central part. Lago Camaleão was 25 % saturated or more with oxygen, thoughout the water column.

5.2. Evaluation of fishing methods

By using gill nets and seines of different mesh sizes fish of different size, behaviour and activity patterns were caught. We may therefore presume that the total number of species indicated for the lake itself is only slightly underestimated. However, it was impossible to fish inside *Echinochloa polystachya* stands in deep water. Small scale migrations of fish shoals in the area may explain the absence of some species in some months. Small juveniles and adults of very small species pass easily through the meshes, and therefore are probably underrepresented. The same may be true for large eel-shaped species such as *Synbranchus marmoratus, Electrophorus electricus* and *Lepidosiren paradoxa.*

The total number of species at station A in front of the lake inlet, is probably grossly underestimated. Large fish could avoid the beach seines, while bottom living animals were sometimes not collected because the water was too deep for the nets. Many species were probably missed because they entered *Echinochloa polystachya* stands, which were well oxygenated due to water exchange with the river, but did not permit fishing with the seine and gill nets. However the fish fauna of these large, well oxygenated macrophyte communities which are considered as specific habitats, will be studied separately, as well as the fish fauna in better oxygenated lakes, the flooded forest and the river itself.

The application of two different fishing techniques which have different selectivities for the fish, with respect to species behaviour, size of the species and body shape, does not allow a quantitative evaluation of the fish community. Therefore, information on species abundance is given in very general terms only. Quantitative studies on recruitment problems were made in the same area in 1978/79 and will proved substantial additional information (BAYLEY, pers. comm.). In spite of methodological restrictions the following conclusions can be drawn.

5.3. Species richness*)

Total number of species is high in the study area. However, there are considerable differences in the individual figures of accumulative species numbers at the different stations (Fig. 5). At all stations, increase of species numbers at the beginning is explained by the fact that sampling techniques and effort collected a representative spectrum of species only after several months, because of the low frequency of many species. Further differences are explained by ecological habitat conditions. After an initial increase, the total number of species rose very little during high water at station A. About 55 species were found in this station and period. During low water (September to December) species from other habitats were forced by the drought to migrate into the river, some of them appearing at station A (Fig. 6). During this period, species richness is highest at station A. The final species count was 92 although the increase during the last month was small.

At station B, monthly species richness was low (Fig. 6). Increase in species number was more or less linear during the whole period. Presumably, the frequently changing environmental conditions inhibited the establishment of a characteristic fish community. Fish passed from the bay to the lake and back, or extended their distribution from the bay in direction of the lake, and vice versa, depending on the hydrological and hydrochemical conditions.

At station C, after the initial increase, a steady number of about 40 species was reached. A further small increase occurred during decreasing water-level in 1981, due to immigration into and/or concentration of the species in the shrinking water body. High species richness in the September sample showed this effect. A further increase occurred during high water in 1982. When the water flowed over the levees between May and August, oxygen conditions changed fundamentally, and another 25 species were caught in the lake. Most of them were of species characteristic for the bay in front of the lake, which always had high oxygen levels. However, 7 new species, which had not been captured at the station A or station B also occurred. They were probably short term immigrants from other habitats not sampled during the study, e. g. the river itself and lakes, flooded forests or floating vegetation on the island, not suffering such extreme oxygen deficiency as Lago Camaleão. *Cichla ocellaris* for instance seems to require relatively high oxygen levels and transparent water. These conditions are found throughout most of the year in the big lakes inside Marchantaria island.

5.4. Species frequency and abundance

In tropical ecosystems a high species richness is often correlated with low species frequency, and this is demonstrated by the fish community of the investigated area

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*) The term species richness is used because it does not have quantitative implications as does the term species diversity in some recent publications.

(Fig. 7 - 10). 40 % of total species number were present only once or twice during the investigation period of 20 months. As already mentioned above, fishing was not quantitative. The application of different fishing techniques with different effectiveness does not allow the calculation of abundance values. However, the numbers given in table 3 indicate that the greatest part of the fish community in number and biomass was composed of a few species only.

Several factors may have affected species frequency and abundance in the samples. The high mobility of many species allows them to relocate themselves quickly inside the area. This behaviour is stimulated by the continually changing environmental conditions due to changing hydrological conditions. Species considered typical for the lake or the bay are absent in some monthly samples, probably because they were locally concentrated in areas not sampled.

Another factor affecting frequency in the samples is the formation of shoals, a feature of many species. The species may be present in the area, but be unrecorded if the shoals were not sampled. However, once caught, such species often appear in very great numbers, e. g. *Ctenobrycon spilurus hauxwellianus* and *Odontostilbe fugitiva* in the lake.

Low frequency may in some cases be related to the fact, that species are occasionally immigrating from other areas. The occurrence of *Auchenipterus* cf. *nuchalis* in the lake in March 1981 was probably due to an occasional immigration of a swarm from the bay for a short time. On the other hand, *Electrophorus electricus* and *Lepidosiren paradoxa* have to be considered as typical elements of the lake fauna, even though they were only infrequently caught. In these cases, frequency estimates are insufficient for the characterisation of the fish community, additional biological and autecological information being necessary. Unfortunately, information on the typical species composition of the river itself, the lakes, flooded forest, and macrophyte communities with adequate oxygen supply is still lacking precluding more detailed discussion of the relationship of the collected species to the fish communities of other habitats.

In addition to variation in species frequency, there are obvious differences in age class frequencies. Under strong oxygen deficiency adult specimens of 17 species were found: *Osteoglossum bicirrhosum, Arapaima gigas, Ctenobrycon spilurus hauxwellianus, Tetragonopterus argenteus, Odontostilbe fugitiva, Hoplosternum thoracatum, Callichthys callichthys, Pterigoplichthys multiradiatus, Synbranchus marmoratus, Electrophorus electricus, Lepidosiren paradoxa* and the cichlids. Other species were represented mostly by juveniles, including members of the very abundant subfamilies Prochilodontinae, Curimatinae, Myleinae and Bryconinae, which formed the greatest part of the biomass.

5.5. Quotient of similarity

Out of a total of 132 species caught in the area, 42 species occurred only at station A, 6 at station B, and 18 species at station C. These numbers indicate the existence of distinct communities at stations A and C, whereas the fish fauna of station B lacks specific characteristics. The SOERENSEN quotient of similarity was used to quantitatively describe the similarity of the samples and stations respectively (SOERENSEN 1948). Considering that the fish community at station A changes considerably during low water periods due to species immigration from other habitats, we have divided the species of station A into two groups: A_1 = species occurring during low water, A_2 = species occurring during rising and high water-level. Station C was treated similarly; C_1 includes the species occurring during extreme flood in 1982, when many species from other habitats migrated into the lake, C_2 species at other times. Station B did not show characteristics allowing separation into different groups. With respect to station A, the fish species of the group A_2 may be considered permanent residents and therefore more typical for the habitat. With respect to station C, group C_2 is considered more typical because the species colonize the lake when normal lake conditions and oxygen deficiency prevail. This assumption may be questioned with regard to particular species, but for general comparison it is appropriate.

According to the SOERENSEN quotient station A shows a 54,2 % similarity to station B, and 50,0 % to station C (Fig. 11). The similarity quotient decreases considerably when the separate groups of station A and C are compared with each other, the lowest similarity of 29,9 % being observed between A_2 and C_2, those communities considered typical for the bay and the lake respectively. With respect to station B, there is little effect due to consideration of the subsamples, indicating the intermediate character of the fish community of station B.

A	A_1	A_2	B	C	C_1	C_2	
	93,6	75,7	54,2	50,0	45,5	36,4	A
		65,7	52,8	49,7	46,3	36,4	A_1
			55,5	43,9	42,2	29,9	A_2
				70,5	65,5	63,2	B
					82,2	80,3	C
						53,8	C_1
							C_2

A : Species occurring at station A
A_1: Species occurring at station A during low water (September - December)
A_2: Species occurring at station A during medium and high water (January - August)
B : Species occurring at station B
C : Species occurring at station C
C_1: Species occurring at station C during extreme flood (May - August 1982)
C_2: Species occurring at station C other than during the period of extreme flood

Fig. 11:
SOERENSEN similarity index calculated for the stations and for different periods.

Using the similarity quotient to compare the monthly samples of each station, the pattern is less evident. This can be explained by the high number of species with low frequency. However, at station A differences between the months of low water period on the one hand, and the months of rising and high water on the other hand are detectable. The similarity quotient is higher between months of the same period than between months of different periods (Fig. 12).

J	J	A	S	O	N	D	J	F	M	A	M	
6	6	4	2	3	3	3	6	5	5	4	4	M
	6	5	3	2	2	3	4	5	4	4	4	J
		5	3	3	4	4	5	5	4	5	5	J
			2	2	2	2	4	3	3	4	3	A
				5	4	5	2	3	4	4	1	S
					5	6	3	4	4	4	2	O
						5	5	4	5	5	3	N
							5	6	5	5	3	D
								6	6	5	5	J
									6	6	4	F
										7	4	M
											4	A

1 = 10 - 19 %
2 = 20 - 29 %
3 = 30 - 39 %
4 = 40 - 49 %
5 = 50 - 59 %
6 = 60 - 69 %
7 = 70 - 79 %

Fig. 12:
Similarity index according to SOERENSEN for station A (bay in front of the lake)

Station B does not show a distinct pattern. Similarity quotients vary strongly, often being 0 due to high total species diversity and very low species frequency (Fig. 13). – Station C has increased similarity quotients during the months of rising water 1981, high water 1981, low water 1981, rising water 1982, high water 1982 and rising water 1981/82 (April/May, February/March) (Fig. 14). The complex pattern can again be explained by the high number of low frequency species. A rough attempt to divide the fish fauna at the family and sub-family levels, with respect to their habitat preferences is given in table 4.

F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	
3	5	0	*	0	0	0	2	0			5	1	0	0	1	2	2	1	J
	3	0	0	0	0	0	2	0			4	1	1	0	1	2	3	0	F
		0	2	1	0	0	2	1			4	1	0	0	3	2	2	1	M
			1	5	3	6	1	0			1	1	4	2	1	1	1	1	A
				1	2	1	*	*			1	3	1	2	2	1	1	*	M
					5	8	1	0			2	2	5	4	2	2	2	2	J
						5	1	0			1	5	6	5	4	3	3	2	J
							1	0			1	3	6	5	2	2	2	2	A
								2			3	1	1	1	1	2	2	3	S
											0	0	0	0	*	1	1	2	O
												Dry Period							N
													Dry Period						D
												2	1	*	2	3	3	2	J
													5	3	4	4	4	3	F
														6	3	3	3	2	M
															2	3	2	2	A
																3	5	2	M
																	5	4	J
																		3	J

0 = 0 %
* = < 10 %
1 = 10 - 19 %
2 = 20 - 29 %
3 = 30 - 39 %
4 = 40 - 49 %
5 = 50 - 59 %
6 = 60 - 69 %
7 = 70 - 79 %
8 = 80 - 89 %

Fig. 13:
SOERENSEN similarity index calculated monthly at station B

F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	
8	4	6	5	3	6	3	5	5	4	4	4	7	7	6	5	3	4	4	J
	4	5	4	2	6	2	5	6	4	3	3	5	6	5	5	3	4	4	F
		3	3	3	5	2	3	4	4	4	2	4	3	3	2	1	2	2	M
			8	4	7	6	6	4	4	4	4	7	6	5	4	4	4	3	A
				5	7	6	6	3	5	5	3	7	6	5	4	4	3	2	M
					5	6	4	3	4	4	3	3	4	3	2	4	3	2	J
						5	7	5	5	5	4	7	6	5	5	5	4	3	J
							4	2	3	1	2	5	5	5	3	4	3	2	A
								5	6	5	3	5	5	3	5	5	4	4	S
									6	6	3	5	4	3	3	2	3	3	O
										9	4	4	3	1	1	2	2	1	N
											4	4	3	*	1	2	2	1	D
												4	4	3	2	3	2	2	J
													8	6	5	3	3	3	F
														7	5	3	4	3	M
															5	3	3	3	A
																4	5	5	M
																	7	5	J
																		7	J

* = < 10 %
1 = 10 - 19 %
2 = 20 - 29 %
3 = 30 - 39 %
4 = 40 - 49 %
5 = 50 - 59 %
6 = 60 - 69 %
7 = 70 - 79 %
8 = 80 - 89 %
9 = 90 - 99 %

Fig. 14:
SOERENSEN similarity index calculated monthly at station C

Table 4: Families and subfamilies of fish occurring at Lago Camaleão at different oxygen concentrations

Station A	Station B	Station C
(during rising and high water-level) high oxygen levels	(during low water-level) high oxygen levels	oxygen deficiency
		Osteoglossidae
		Erythrinidae
		Electrophoridae
		Callichthyidae
		Loricariidae
		Synbranchidae
		Lepidosirenidae
		Cichlidae
	Anostomidae	← Anostomidae
	Prochilodontinae	← Prochilodontinae
	Curimatinae	← Curimatinae
	Serrasalminae	
	Myleinae	← Myleinae
Bryconinae	Bryconinae	← Bryconinae
Gymnotoidei	Gymnotoidei	
Doradidae	Doradidae	
Auchenipteridae	Auchenipteridae	
Ageneiosidae	Ageneiosidae	
Pimelodidae	Pimelodidae	
Hypophthalmidae	Hypophthalmidae	
Sciaenidae	Sciaenidae	
Tetraodontidae	Tetraodontidae	
Clupeidae	Clupeidae	
Engraulidae	Engraulidae	

5.6. Seasonal changes

With rising water-level, Lago Camaleão gradually floods coinciding with the main spawning season of most of the species. Some spawn in the lake itself, e. g. *Hoplosternum thoracatum* and *Callichthys callichthys*, whose nests of plant material and air bubbles were frequently found floating on the surface. Most of the species, however, spawn outside. To what extent eggs and larvae drift passively into the lake with inflowing Amazon water is uncertain. Obviously there is an extensive migration of fingerlings and, to a lesser degree adults, from the bay into the lake. For instance young tambaqui (*Colossoma macropomum*) of about 10 cm length were found within recently flooded dense terrestrial vegetation, 3 km from the entrance. At the same time, lake species start to desappear or diminsh drastically in numbers in the bay.

During peak flood a lateral exchange of ichthyofauna between Lago Camaleão and other lakes on the island seems to occur, because there are no longer any boundaries between them. This may explain the appearance of species formerly found neither in Lago Camaleão nor in the bay, e. g. *Pterophyllum scalare.*

As the water goes down, many species begin to leave the floodplain, entering the river. High species diversity was found in the bay already in August, when the water-level was still relatively high. At the same time, the fishes remaining in the floodplain are crowded in the shrinking waterbodies and during this period the highest fish densities were observed, reaching 1 - 3 t/ha in Lago Camaleão. Soon before connection with the river is broken, many species leave the lake in large quantities. Such a migration pattern explains the plentiful occurrence of *Triportheus* spp. in August but their complete absence from the remaining pools one month later.

During low water, diversity was very low; in the remaining pools only 19 species were caught in November/December. Most of the lake species were caught in the bay in front of the lake during this period. Mortality seems to be very high, also recorded for other floodplains during dry period (BONETTO et al. 1969, UNIVERSITY OF MICHIGAN et al. 1971). The fish remaining in the evaporating pools are eaten by birds which congregate in great numbers around the pools, while almost the entire fish fauna dies when the pools dry out completely. Exceptions are *Synbranchus marmoratus* and *Lepidosiren paradoxa,* which survive in burrows in the mud. Young *Arapaima gigas* and *Hoplosternum thoracatum* are also resistent; they live in liquid mud.

5.7. Respiratory strategies

Adaptations by fish to low oxygen concentrations have been described for many tropical regions. In South and Middle America there are works on the waters of the rainforest areas of British Guiana (CARTER 1935), the swamps of the Paraguayan Chaco (CARTER and BEADLE 1931), on the Rio Uruguay and Rio de la Plata (ANGELESCU and GNERI 1949), on a pool in Venezuela (BEEBE 1945), on a lowland stream in Panama (KRAMER and GRAHAM 1976), on the Rio Negro (GEISLER 1969), and on the Amazon (KRAMER et al. 1978).

Air-breathing is a very common adaptation of Amazonian fish to low oxygen concentrations and about 9 or 10 families have air-breathing representatives (KRAMER et al. 1978). Much less information is available on the many non-air-breathing species which occur in the same habitats under low oxygen concentrations. LEWIS (1970) demonstrated that Cyprinodontids are even able to survive anoxic conditions, utilize the surface water layer. BRAUM and JUNK (1982) described a new morphological adaptation of non air-breathing Amazonian species to low oxygen concentrations, while physiological adaptations have been described by several authors (DRIEDZIC et al. 1978; ISAACK et al. 1978; JOHANSEN et al. 1978a, b; SAINT-PAUL 1982).

Out of about 40 species occurring inside Lago Camaleão during the period of lowest oxygen concentrations 12 are known to be air-breathers, and 7 to be non air-breathers with additional morphological adaptations for better utilization of the oxygen rich surface layer. For 1 species (*Hoplias malabaricus*) physiological adaptations only are described (Tab. 5). Presumably other species occurring frequently in the area also have various adaptations while species with already described adaptations could have additional mechanisms not yet described to survive the extremely low oxygen concentrations.

In the bay outside the lake, influenced by oxygen-rich water from the Amazon, the number of species with adaptations to low oxygen concentrations was much lower: 15 out of 92 species (= 16 %) had morphological, anatomical and/or physiological adaptations to survive hypoxia. (Myleinae and Bryconinae lips, Callichthyidae and Loricariidae air-breathers). Some of them are considered short term immigrants from other habitats e. g. Callichthyidae and some Loricariidae. The limiting effect of oxygen concentrations on the species composition in the lake is well demonstrated during extreme high water (May - August 1982). With improving oxygen conditions many species which formerly occurred only at station A, where good oxygen conditions always prevailed migrated into the lake.

5.8. Adaptations to oxygen deficiency and survival strategies

Considering the extremely unfavourable oxygen conditions, what advantages accrue to fish which colonize such habitats? The disadvantages are obvious. Low oxygen concentrations force the fish to expend much energy and time in the search for oxygen, for instance coming up to the surface to swallow air, or staying near the surface to use the oxygen-rich surface layer. This may increase the danger of being caught by predators. Food diversity is considerably reduced because phytoplankton and zooplankton become very scarce in the lake. The bottom fauna is completely lacking, because of the lack of oxygen, and several animals which are of great importance as fish food, like freshwater shrimps (*Macrobrachium* spp.) and Conchostraca (*Cyclestheria hislopi*) are absent from the perizoon. There is no information on the impact of organically highly polluted water on the health of fish, but this could also be a deleterious factor.

On the other hand, there do seem to be two advantages. Firstly, interspecific competition for food is reduced. A relatively small number of species utilize the existing food sources and although this sources are somewhat impoverished, detritus, periphyton, perizoon, aquatic macrophytes, terrestrial and semiaquatic arthropods from the floating vegetation and the inundated forest, plus fruits and seeds are available.

The other, probably greater advantage is reduction in predators which occurs under extremely low oxygen concentrations. Only the following predatory fish species occurred: *Hoplias malabaricus, Hoplerythrinus unitaeniatus, Arapaima gigas, Serrasalmus nattereri, Serrasalmus* sp., *Surubim lima* and *Electrophorus electricus*. Facultative fish predators like

Table 5: List of fish species occurring in Lago Camaleão with previously described, additional respiration mechanisms

FAM. ERYTHRINIDAE		
Hoplias malabaricus	Physiological adaptations	DRIEDZIC et al. 1978
Hoplerythrinus unitaeniatus	Air breather (buccal cavity)	WEIBEZAHN 1967; LÜLING 1964
FAM. SERRASALMIDAE SUBFAM. MYLEINAE		
Colossoma macropomum	Morphological adaptations (swollen lips)	BRAUM and JUNK 1982
Colossoma bidens	" "	Pers. observations
Mylossoma duriventre	" "	Pers. observations
FAM. CHARACIDAE SUBFAM. BRYCONINAE		
Brycon cf. *melanopterus*	Morphological adaptations	Pers. observations
Triportheus angulatus	(swollen lips)	Pers. observations
Triportheus albus	" "	Pers. observations
FAM. OSTEOGLOSSIDAE		
Arapaima gigas	Air breather (gas bladder) Physiological adaptations	STEVENS and HOLETON 1978 RANDALL et al. 1978; HOCHACHKA et al. 1978
Osteoglossum bicirrhosum	Morphological adaptations (Lips) Physiological adaptations	KRAPP 1975; JOHANSEN et al. 1978a
FAM. CALLICHTHYIDAE		
Hoplosternum thoracatum	Air breather (intestine)	CARTER and BEADLE 1931; GEE 1976
Callichthys callichthys	Air breather (intestine)	KRAMER and GRAHAM 1976
Corydoras sp.	Air breather (intestine)	
FAM. LORICARIIDAE		
Pterygoplichthys multiradiatus	Air breather (stomach)	CARTER and BEADLE 1931; CARTER 1935; GEE 1976; GRADWELL 1971; KRAMER and GRAHAM 1976; JOHANSEN et al. 1978b
FAM. SYNBRANCHIDAE		
Synbranchus marmoratus	Air breather (branchial chamber)	LÜLING 1958; JOHANSEN 196 ROSA 1977
FAM. ELECTROPHORIDAE		
Electrophorus electricus	Air breather (buccal cavity)	CARTER 1935; JOHANSEN et al. 1968; GAREY and RAHN 1970; FARBER and RAHN 197 DORN 1973
FAM. CICHLIDAE		
Cichlasoma bimaculatum	Air breather (stomach) ?	LOWE-McCONNELL 1964
FAM. LEPIDOSIRENIDAE		
Lepdosiren paradoxa	Air breather (lungs)	KERR 1900; CARTER and BEADLE 1931

Synbranchus marmoratus, Osteoglossum bicirrhosum and *Lepidosiren paradoxa,* which mostly feed on aquatic and terrestrial insects, but sometimes feed on fish, also occurred but all predators occurred in very low numbers only. The piranhas and *Surubim lima* are only occasional immigrants, as they seem to be unable to colonize habitats with strong oxygen deficiency for extensive periods. Probably the only really important fish predator is *Arapaima gigas.* Predatory specimens comprised less than 5 % of the total biomass. These results do not correspond with the generally reported high percentages of predatory species and high predation pressure on the Amazonian fish fauna (LOWE-McCONNELL 1975; WELCOMME 1979).

Other fish predators, crocodiles, herons, cormorants and kingfishers, occurred in the lake as well as in the bay. Fresh water dolphins (*Inia geoffrensis, Sotalia fluviatilis*) were observed only in the bay in front of the lake. In this area, predatory fish species were much more numerous both in species number and abundance. 36 predators or facultative predators were collected, i. e. 39 % of the total species number. Some of these may be numerically underestimated because of the collecting methods e. g. the big catfishes and the condirus (Trichomycteridae). Fish caught in gillnets at station A frequently showed signs of candiru attack. About 30 % of the total ichthyomass captured at station A were predatory species, suggesting a strong predation pressure.

The occurrence of many juvenile fish under hypoxic conditions may be related to low predation pressure too. Juveniles, being more susceptible to predators than adult fish may colonize oxygen deficient habitats to escape predation pressure, in spite of the unfavourable environmental conditions. Studies on this subject are in progress.

Considering the impressive resistance of many fish species to low oxygen levels, one must however ask why so many fishes die due to oxygen deficiency during cold fronts (GEISLER 1969; SANTOS 1973). Fishermen have long known that fish are affected by oxygen deficiency to different degrees. Species lacking adaptations die first and in much greater numbers than species with adaptations. However, species with adaptative mechanisms are killed as well, probably because some of the adaptation mechanisms need time to be activated, particularly when they have not been used for a long period. For example, lip formation in *Brycon* cf. *melanopterus* and *Colossoma macropomum* require several hours (BRAUM and JUNK 1982). When extreme oxygen deficiency occurs rapidly the fish die, as shown at the fish culture station at INPA. The reported increase in total haemoglobin in blood and increase of total erythrocyte surface area in *Colossoma macropomum* under low oxygen concentrations (SAINT-PAUL 1982) also requires time to develop. Furthermore, direct intoxication due to increased amounts of H_2S in the surface water layer must also be considered.

6. Summary

Over a period of 20 months the fish fauna distribution at Lago Camaleão, a floodplain lake of the Amazon near Manaus was studied. Special attention was given to the oxygen conditions. The lake was strongly deficient in oxygen for long periods, the surface oxygen concentrations during the day often being only about 0,5 g O_2/l. Appoximately 25.000 specimens were captured; 132 species belonging to 94 genera, 31 families and 10 orders were identified. About 40 species were able to live under

extremely low oxygen concentrations. 12 of these were air breathers. Another 8 are known to possess other morphological, anatomical and/or physiological adaptations to oxygen deficiency. It is presumed that the other species occurring in the area may have adaptations too.

Survival strategies in respect to oxygen deficiency are discussed. It is suggested that the colonization of strongly oxygen deficient habitats reduces interspecific competition for food and diminishes predation pressure on the fish community, the total number of predatory fish species and specimens being much lower under low oxygen concentrations.

7. Resumo

Durante um período de 20 meses, foi estudada a distribuição da ictiofauna no lago Camaleão, lago de Várzea do Rio Amazonas, próximo a Manaus. Especial atenção foi dada às concentraçoẽs de oxigênio, visto que o lago apresentou-se deficiente em oxigênio por longos períodos, atingindo com frequência apenas durante o dia o valor de 0,5 mg O_2/l, na superfície. Das amonstragens feitas durante este período, resultou em cerca de 25.000 especimens de peixes pertencentes à 10 ordens, 31 famílias, 94 gêneros e 132 espécies. Apoximadamente 40 espécies foram capazes de viver em condicões fortemente deficientes em oxigênio, sendo que 12 apresentaram respiração aérea e 8 espécies outras adaptações morfológicas, anatômicas e/ou fisiológicas já descritas. Com relação às especies restantes, sugerese que tambem possuam adaptaçoẽs para viver em baixas concentraçoẽs de oxigênio.

Estratégias de sobrevivência em relação à deficiência em oxigênio estão sendo discutidas. Sugerese, que a colonização de habitats fortemente deficientes em oxigênio reduz a competição interespecífica para ítens alimentares e diminue a pressão predatória para a comunidade íctica, sendo o número total de espécies e espécimes de peixes carnívoros fortemente reduzido em condições de baixas concentrações de oxigênio.

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